



**CHEMISTRY  
HIGHER LEVEL  
PAPER 1**

Monday 18 May 2009 (afternoon)

1 hour

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**INSTRUCTIONS TO CANDIDATES**

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- The periodic table is provided for reference on page 2 of this examination paper.

The Periodic Table

1	2	3	4	5	6	7	0											
<div>1 H 1.01</div>		<div>Atomic Number</div> <div>Element</div> <div>Atomic Mass</div>						<div>2 He 4.00</div>										
<div>3 Li 6.94</div>	<div>4 Be 9.01</div>							<div>5 B 10.81</div> <div>6 C 12.01</div> <div>7 N 14.01</div> <div>8 O 16.00</div> <div>9 F 19.00</div> <div>10 Ne 20.18</div>										
<div>11 Na 22.99</div>	<div>12 Mg 24.31</div>							<div>13 Al 26.98</div> <div>14 Si 28.09</div> <div>15 P 30.97</div> <div>16 S 32.06</div> <div>17 Cl 35.45</div> <div>18 Ar 39.95</div>										
<div>19 K 39.10</div>	<div>20 Ca 40.08</div>	<div>21 Sc 44.96</div>	<div>22 Ti 47.90</div>	<div>23 V 50.94</div>	<div>24 Cr 52.00</div>	<div>25 Mn 54.94</div>	<div>26 Fe 55.85</div>	<div>27 Co 58.93</div>	<div>28 Ni 58.71</div>	<div>29 Cu 63.55</div>	<div>30 Zn 65.37</div>	<div>31 Ga 69.72</div>	<div>32 Ge 72.59</div>	<div>33 As 74.92</div>	<div>34 Se 78.96</div>	<div>35 Br 79.90</div>	<div>36 Kr 83.80</div>	
<div>37 Rb 85.47</div>	<div>38 Sr 87.62</div>	<div>39 Y 88.91</div>	<div>40 Zr 91.22</div>	<div>41 Nb 92.91</div>	<div>42 Mo 95.94</div>	<div>43 Tc 98.91</div>	<div>44 Ru 101.07</div>	<div>45 Rh 102.91</div>	<div>46 Pd 106.42</div>	<div>47 Ag 107.87</div>	<div>48 Cd 112.40</div>	<div>49 In 114.82</div>	<div>50 Sn 118.69</div>	<div>51 Sb 121.75</div>	<div>52 Te 127.60</div>	<div>53 I 126.90</div>	<div>54 Xe 131.30</div>	
<div>55 Cs 132.91</div>	<div>56 Ba 137.34</div>	<div>57 † La 138.91</div>	<div>72 Hf 178.49</div>	<div>73 Ta 180.95</div>	<div>74 W 183.85</div>	<div>75 Re 186.21</div>	<div>76 Os 190.21</div>	<div>77 Ir 192.22</div>	<div>78 Pt 195.09</div>	<div>79 Au 196.97</div>	<div>80 Hg 200.59</div>	<div>81 Tl 204.37</div>	<div>82 Pb 207.19</div>	<div>83 Bi 208.98</div>	<div>84 Po (210)</div>	<div>85 At (210)</div>	<div>86 Rn (222)</div>	
<div>87 Fr (223)</div>	<div>88 Ra (226)</div>	<div>89 ‡ Ac (227)</div>																
†																		<div>71 Lu 174.97</div>
‡																		<div>103 Lr (260)</div>

1. What is the number of oxygen atoms in one mole of  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ ?
  - A. 5
  - B. 9
  - C.  $6.0 \times 10^{23}$
  - D.  $5.4 \times 10^{24}$
  
2. Which sample has the greatest mass?
  - A.  $6.0 \times 10^{25}$  molecules of hydrogen
  - B. 5.0 mol of neon atoms
  - C.  $1.2 \times 10^{24}$  atoms of silver
  - D.  $1.7 \times 10^2$  g of iron
  
3. What volume of sulfur trioxide, in  $\text{cm}^3$ , can be prepared using  $40 \text{ cm}^3$  sulfur dioxide and  $20 \text{ cm}^3$  oxygen gas by the following reaction? Assume all volumes are measured at the same temperature and pressure.
 
$$2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{SO}_3(\text{g})$$
  - A. 20
  - B. 40
  - C. 60
  - D. 80
  
4. Which sample of nitrogen gas,  $\text{N}_2$ , contains the greatest number of nitrogen molecules?
  - A. 1.4 g  $\text{N}_2$
  - B.  $1.4 \text{ dm}^3$  of  $\text{N}_2$  at  $1.01 \times 10^5 \text{ Pa}$  and 273 K
  - C.  $1.4 \times 10^{23}$   $\text{N}_2$  molecules
  - D. 1.4 mol  $\text{N}_2$

5. The table below shows the number of protons, neutrons and electrons present in five species.

Species	Number of protons	Number of neutrons	Number of electrons
X	6	8	6
Y	7	7	7
Z	7	7	8
W	8	8	8
Q	8	10	8

Which **two** species are isotopes of the same element?

- A. X and W
  - B. Y and Z
  - C. Z and W
  - D. W and Q
6. What is the order of increasing energy of the orbitals within a single energy level?
- A.  $d < s < f < p$
  - B.  $s < p < d < f$
  - C.  $p < s < f < d$
  - D.  $f < d < p < s$
7. What is the electron configuration of the  $\text{Cr}^{2+}$  ion?
- A.  $[\text{Ar}] 3d^5 4s^1$
  - B.  $[\text{Ar}] 3d^3 4s^1$
  - C.  $[\text{Ar}] 3d^6 4s^1$
  - D.  $[\text{Ar}] 3d^4 4s^0$

8. Which statement describes the trends of electronegativity values in the periodic table?
- Values increase from left to right across a period and increase down a group.
  - Values increase from left to right across a period and decrease down a group.
  - Values decrease from left to right across a period and increase down a group.
  - Values decrease from left to right across a period and decrease down a group.
9. Which equation best represents the first ionization energy of magnesium?
- $\text{Mg(s)} \rightarrow \text{Mg}^+(\text{s}) + \text{e}^-$
  - $\text{Mg(g)} \rightarrow \text{Mg}^{2+}(\text{g}) + 2\text{e}^-$
  - $\text{Mg(g)} \rightarrow \text{Mg}^+(\text{g}) + \text{e}^-$
  - $\text{Mg(s)} \rightarrow \text{Mg}^+(\text{g}) + \text{e}^-$
10. What are the products of the reaction between chlorine and water?
- $\text{O}_2$ ,  $\text{H}_2$  and  $\text{HCl}$
  - $\text{H}_2$  and  $\text{OCl}_2$
  - $\text{HCl}$  and  $\text{HOCl}$
  - $\text{HOCl}$ ,  $\text{H}_2$  and  $\text{Cl}_2$
11. Which statement best describes the **intramolecular** bonding in  $\text{HCN(l)}$ ?
- Electrostatic attractions between  $\text{H}^+$  and  $\text{CN}^-$  ions
  - Only van der Waals' forces
  - Van der Waals' forces and hydrogen bonding
  - Electrostatic attractions between pairs of electrons and positively charged nuclei

12. How many bonding pairs and lone pairs of electrons surround the sulfur atom in the  $\text{SF}_4$  molecule?

	Bonding pairs	Lone pairs
A.	4	1
B.	4	0
C.	6	0
D.	8	2

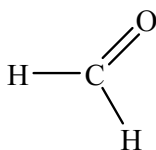
13. Metal M has only one oxidation number and forms a compound with the formula  $\text{MCO}_3$ . Which formula is correct?

- A.  $\text{MNO}_3$
- B.  $\text{MNH}_4$
- C.  $\text{MSO}_4$
- D.  $\text{MPO}_4$

14. Which of the following best describes the formation of  $\pi$  bonds?

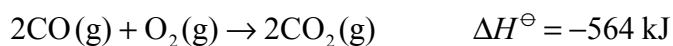
- A. They are formed by the sideways overlap of parallel orbitals.
- B. They are formed by the axial overlap of orbitals.
- C. They are formed by the sideways overlap of an s and p orbital.
- D. They are formed by the axial overlap of either s or p orbitals.

15. What is the hybridization of the carbon atom, and the number of  $\sigma$  and  $\pi$  bonds in the methanal molecule?



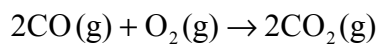
	Hybridization	$\sigma$ bonds	$\pi$ bonds
A.	$sp^2$	3	1
B.	$sp^3$	3	1
C.	$sp^3$	4	0
D.	$sp^2$	4	0

16. What is the energy, in kJ, released when 1.00 mol of carbon monoxide is burned according to the following equation?



- A. 141
- B. 282
- C. 564
- D. 1128
17. The specific heat of iron is  $0.450 \text{ J g}^{-1} \text{ K}^{-1}$ . What is the energy, in J, needed to increase the temperature of 50.0 g of iron by 20.0 K?
- A. 9.00
- B. 22.5
- C. 45.0
- D. 450

18. What is the standard entropy change,  $\Delta S^\ominus$ , for the following reaction?

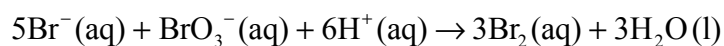


	<b>CO(g)</b>	<b>O<sub>2</sub>(g)</b>	<b>CO<sub>2</sub>(g)</b>
$S^\ominus / \text{J K}^{-1} \text{mol}^{-1}$	198	205	214

- A. –189
- B. –173
- C. +173
- D. +189
19. Which step(s) is/are endothermic in the Born-Haber cycle for the formation of LiCl?
- A.  $\frac{1}{2}\text{Cl}_2\text{(g)} \rightarrow \text{Cl(g)}$  **and**  $\text{Li(s)} \rightarrow \text{Li(g)}$
- B.  $\text{Cl(g)} + \text{e}^- \rightarrow \text{Cl}^-\text{(g)}$  **and**  $\text{Li(g)} \rightarrow \text{Li}^+\text{(g)} + \text{e}^-$
- C.  $\text{Li}^+\text{(g)} + \text{Cl}^-\text{(g)} \rightarrow \text{LiCl(s)}$
- D.  $\frac{1}{2}\text{Cl}_2\text{(g)} \rightarrow \text{Cl(g)}$  **and**  $\text{Cl(g)} + \text{e}^- \rightarrow \text{Cl}^-\text{(g)}$
20. What is the function of iron in the Haber process?
- A. It shifts the position of equilibrium towards the products.
- B. It decreases the rate of the reaction.
- C. It provides an alternative reaction pathway with a lower activation energy.
- D. It reduces the enthalpy change of the reaction.



21. Consider the following reaction.



The rate expression for the reaction is found to be:

$$\text{rate} = k [\text{Br}^-][\text{BrO}_3^-][\text{H}^+]^2$$

Which statement is correct?

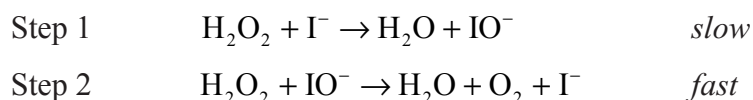
- A. The overall order is 12.
  - B. Doubling the concentration of all of the reactants at the same time would increase the rate of the reaction by a factor of 16.
  - C. The units of the rate constant,  $k$ , are  $\text{mol dm}^{-3} \text{s}^{-1}$ .
  - D. A change in concentration of  $\text{Br}^-$  or  $\text{BrO}_3^-$  does not affect the rate of the reaction.
22. The rate expression for a reaction is:

$$\text{rate} = k [\text{X}][\text{Y}]$$

Which statement is correct?

- A. As the temperature increases the rate constant decreases.
- B. The rate constant increases with increased temperature but eventually reaches a constant value.
- C. As the temperature increases the rate constant increases.
- D. The rate constant is not affected by a change in temperature.

23. Consider the following reaction mechanism.



Which statement correctly identifies the rate-determining step and the explanation?

- A. Step 2 because it is the faster step
  - B. Step 1 because it is the slower step
  - C. Step 1 because it is the first step
  - D. Step 2 because it is the last step
24. Which statement is correct for the equilibrium  $\text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_2\text{O}(\text{g})$  in a closed system at 100 °C?
- A. All the  $\text{H}_2\text{O}(\text{l})$  molecules have been converted to  $\text{H}_2\text{O}(\text{g})$ .
  - B. The rate of the forward reaction is greater than the rate of the reverse reaction.
  - C. The rate of the forward reaction is less than the rate of the reverse reaction.
  - D. The pressure remains constant.
25. Which are definitions of an acid according to the Brønsted-Lowry and Lewis theories?

	Brønsted-Lowry theory	Lewis theory
A.	proton donor	electron pair acceptor
B.	proton acceptor	electron pair acceptor
C.	proton acceptor	electron pair donor
D.	proton donor	electron pair donor

26. 100 cm<sup>3</sup> of a NaOH solution of pH 12 is mixed with 900 cm<sup>3</sup> of water. What is the pH of the resulting solution?
- A. 1
- B. 3
- C. 11
- D. 13

27. Ammonia acts as a weak base when it reacts with water. What is the  $K_b$  expression for this reaction?

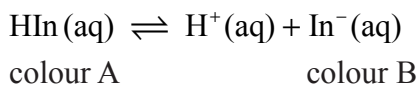
A.  $\frac{[\text{NH}_4^+][\text{OH}^-]}{[\text{NH}_3][\text{H}_2\text{O}]}$

B.  $\frac{[\text{NH}_3][\text{H}_2\text{O}]}{[\text{NH}_4^+][\text{OH}^-]}$

C.  $\frac{[\text{NH}_3]}{[\text{NH}_4^+][\text{OH}^-]}$

D.  $\frac{[\text{NH}_4^+][\text{OH}^-]}{[\text{NH}_3]}$

28. The indicator, HIn is used in a titration between an acid and base. Which statement about the dissociation of the indicator, HIn is correct?

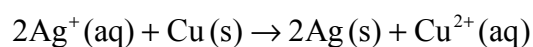


- A. In a strongly alkaline solution, colour B would be observed.
- B. In a strongly acidic solution, colour B would be observed.
- C.  $[\text{In}^-]$  is greater than  $[\text{HIn}]$  at the equivalence point.
- D. In a weakly acidic solution colour B would be observed.

29. At the same concentration, which acid would have the lowest pH?

- A.  $\text{HNO}_2$   $K_a = 5.6 \times 10^{-4} \text{ mol dm}^{-3}$
- B.  $\text{HF}$   $K_a = 6.8 \times 10^{-4} \text{ mol dm}^{-3}$
- C.  $\text{C}_6\text{H}_5\text{COOH}$   $K_a = 6.3 \times 10^{-5} \text{ mol dm}^{-3}$
- D.  $\text{HCN}$   $K_a = 4.9 \times 10^{-10} \text{ mol dm}^{-3}$

30. Which species is oxidized in the following reaction?

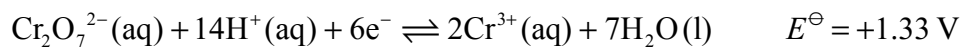


- A.  $\text{Ag}^+$
- B.  $\text{Cu}$
- C.  $\text{Ag}$
- D.  $\text{Cu}^{2+}$

31. Which list represents the halogens in **increasing** order of oxidizing strength (weakest oxidizing agent first)?

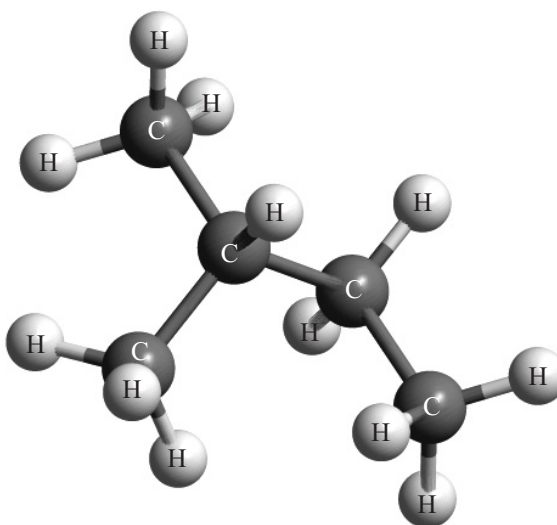
- A.  $\text{Cl}_2$   $\text{I}_2$   $\text{Br}_2$
- B.  $\text{I}_2$   $\text{Br}_2$   $\text{Cl}_2$
- C.  $\text{I}_2$   $\text{Cl}_2$   $\text{Br}_2$
- D.  $\text{Cl}_2$   $\text{Br}_2$   $\text{I}_2$

32. What is the cell potential, in V, for the reaction that occurs when the following two half-cells are connected?



- A. +0.01
- B. +0.89
- C. +1.77
- D. +2.65
33. What structural feature must a molecule have in order to undergo addition polymerization?
- A. Two functional groups
- B. A carbon–carbon double bond
- C. Carbon atoms singly bonded together
- D. A polar covalent bond
34. What is the product of the oxidation of butan-2-ol?
- A. But-2-ene
- B. Butanoic acid
- C. Butanal
- D. Butanone

35. What is the IUPAC name of the following compound?



- A. 2-methylbutane
- B. Ethylpropane
- C. 3-methylbutane
- D. Pentane

36. Which equations represent the incomplete combustion of methane?

- I.  $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})$
- II.  $\text{CH}_4(\text{g}) + 1\frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{CO}(\text{g}) + 2\text{H}_2\text{O}(\text{g})$
- III.  $\text{CH}_4(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{C}(\text{s}) + 2\text{H}_2\text{O}(\text{g})$

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

37. What is the organic product of the reaction between  $\text{CH}_3\text{CH}_2\text{NH}_2$  and  $\text{CH}_3\text{CH}_2\text{COOH}$ ?
- $\text{CH}_3\text{CH}_2\text{NHCOCH}_2\text{CH}_3$
  - $\text{CH}_3\text{CH}_2\text{CH}_2\text{NHCOCH}_3$
  - $\text{CH}_3\text{CH}_2\text{NHCOCH}_3$
  - $\text{CH}_3\text{NHCOCH}_3$
38. What is the IUPAC name of the compound  $\text{CH}_3\text{CH}_2\text{COOCH}_2\text{CH}_3$ ?
- Ethyl ethanoate
  - Propyl ethanoate
  - Ethyl propanoate
  - Pentyl propanoate
39. Which statement is correct about the enantiomers of a chiral compound?
- Their physical properties are different.
  - All their chemical reactions are identical.
  - A racemic mixture will rotate the plane of polarized light.
  - They will rotate the plane of polarized light in opposite directions.
40. Which would be the best method to decrease the **random** uncertainty of a measurement in an acid-base titration?
- Repeat the titration
  - Ensure your eye is at the same height as the meniscus when reading from the burette
  - Use a different burette
  - Use a different indicator for the titration